(12) UK Patent Application (19) GB (11) 2 359 452 (13) A

(43) Date of A Publication 22.08.2001

(21) Application No 0003562.6

(22) Date of Filing 17.02.2000

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(51) INT CL^7
H04Q 7/38 // H04Q 7/36

(52) UK CL (Edition S)
H4L LRRMW L1H10 L209

(56) Documents Cited
GB 2260879 A

(58) Field of Search
UK CL (Edition R) **H4L LDSWD LDSWX**
INT CL^7 **H04Q 7/36 7/38**
Online: WPI, JAPIO, EPODOC

(54) Abstract Title

Allocation of channels in a pico-cell system

(57) A pico-cell situated within a building 1 shares a number of traffic channels with the external maco-cells 2, 3, 4, 5, 6. Upon establishing a communication link with the pico-cell base station the interference present on the broadcast channels BCCHs 92, 94, 96, 98, 100 of the surrounding cells is measured by a mobile 13 inside the building and compared against a threshold. A traffic channel 102, 104, 106, 108, 110 associated with a cell whose interference level is considered to meet the threshold is assigned to the mobile station. If none of the of the cells are considered to meet the threshold the pico-cell's own BCCH 90 is assigned to the mobile. Carrier to interference ratio may be used to determine the interference.

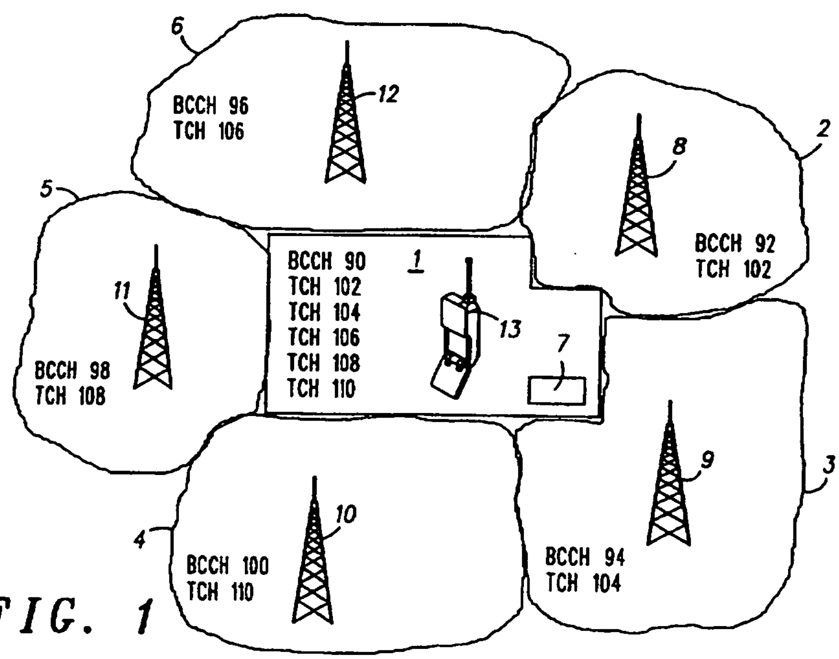

FIG. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

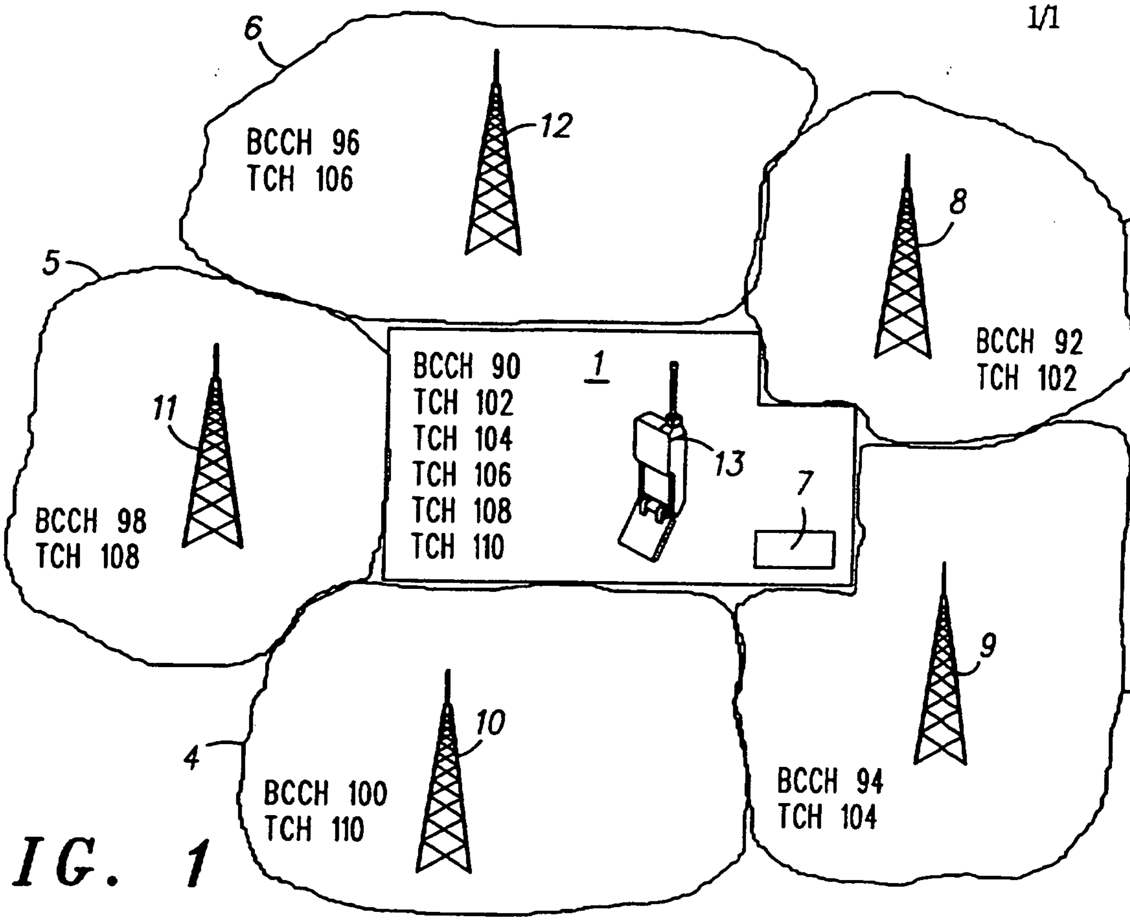
6
12
BCCH 96
TCH 106
2
8
5
BCCH 92
TCH 102
BCCH 90
TCH 102
TCH 104
TCH 106
TCH 108
TCH 110
1
13
7
11
BCCH 98
TCH 108
9
3
10
4
BCCH 94
TCH 104
BCCH 100
TCH 110

FIG. 1

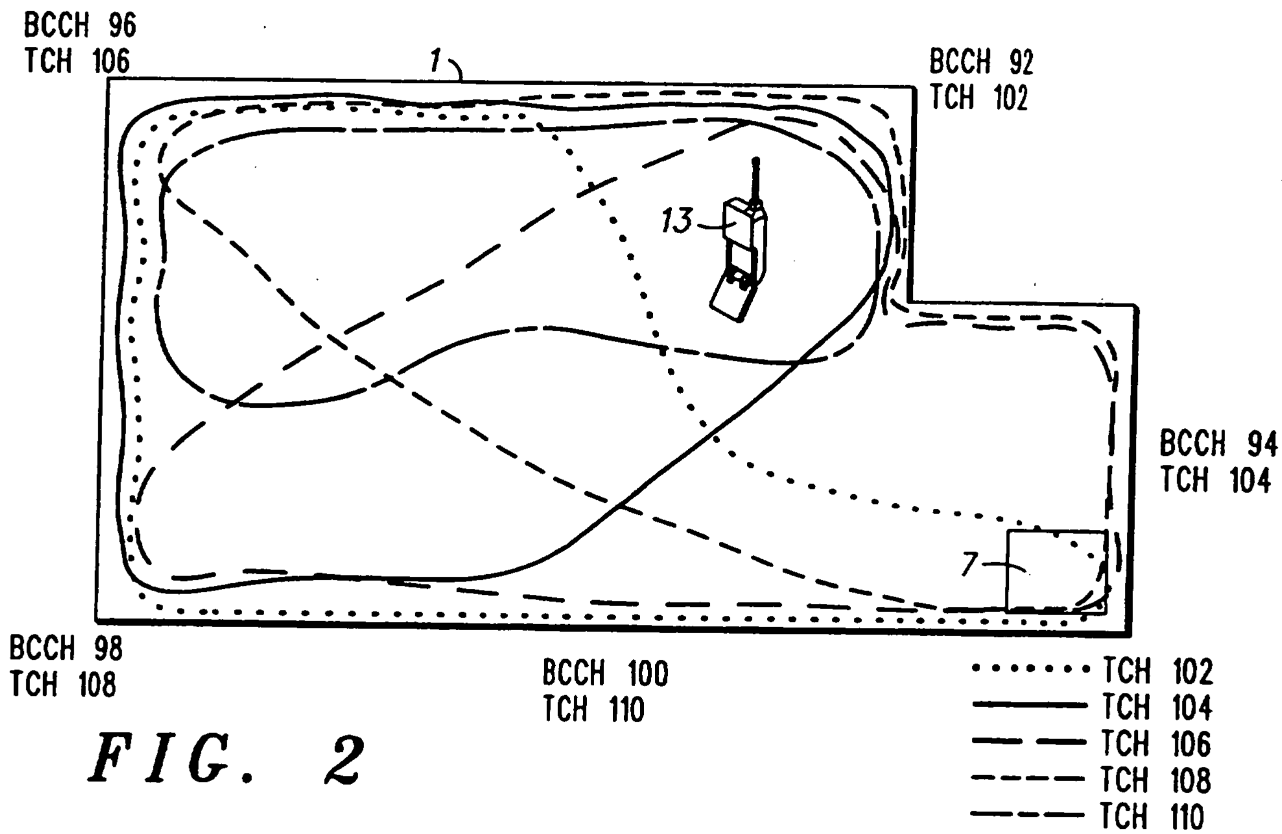
BCCH 96
TCH 106
1
BCCH 92
TCH 102
13
BCCH 94
TCH 104
7
BCCH 98
TCH 108
BCCH 100
TCH 110
TCH 102
TCH 104
TCH 106
TCH 108
TCH 110

FIG. 2

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CELLULAR COMMUNICATIONS SYSTEM FOR BUILDINGS AND METHODS OF CHANNEL ALLOCATION

This invention relates to in-building cellular communications systems and particularly to means of channel allocation in such systems.

Cellular communications systems generally include a switch controller coupled to the public-switched telephone network (PSTN) and a plurality of base-stations. One or more mobile stations communicate, over communication channels, with a base-station that facilitates a call between the mobile station and the PSTN.

A particular type of cellular communications system, to which this invention is particularly applicable, is the GSM system (Global System for Mobile Communications), a description of which can be found in the book "The GSM System for Mobile Communications" by M. Mouly and M. Pautet.

GSM networks generally include mobile services switching centres, base-stations and mobile stations. Each of the plurality of base stations generally defines a geographic area or "cell" proximate to other base-station to produce coverage areas. Cell sizes can be as large as 70km in diameter in rural areas or typically 200m in urban areas. As a mobile station moves from one cell to the next, the communication link is transferred from its current serving base-station to a neighbouring base-station using a procedure known as handover or handoff.

In GSM the total available frequency spectrum is divided up into a plurality of 200kHz channels. For example, the GSM 900 frequency spectrum extends between 890MHz and 960MHz.

A single absolute radio frequency channel number (ARFCN) or RF carrier is actually a pair of frequencies, one used in each direction (transmit and receive). This allows information to be passed in both directions. For GSM 900 the paired frequencies are separated by 45MHz. For each cell in a GSM network, at least one ARFCN must be allocated and more may be allocated to provide greater capacity.

The use of multiple access techniques, eg TDMA (Time Division Multiple Access) permits the simultaneous transmission from several mobile stations to a single base-station on the same carrier frequency. The RF carrier in GSM can support up to eight TDMA time slots, ie in theory, each RF carrier is capable of supporting up to eight simultaneous telephone calls. Standard GSM has a total of 124 frequencies available for use in a network but most network providers are unlikely to be able to use all of these frequencies and are generally allocated a small sub-set of the 124.

As the maximum size of a cell is approximately 70km in diameter, the number of frequencies allocated may not be sufficient to cover the whole of the network provider's operating area. To overcome this limitation, the network provider must re-use the same frequencies over and over again in what is termed a frequency re-use pattern. When planning the frequency re-use pattern, the network planner must take into account how often to use the same frequencies and determine how close together the cells are, otherwise co-channel and/or adjacent channel interference may occur. Co-channel interference occurs when RF carriers of the same frequency are transmitting in close proximity to each other and the transmission from one RF carrier interferes with the other RF carrier. Adjacent channel interference occurs when an RF source of a nearby frequency interferes with the RF carrier.

The communications channels of the GSM system are designated as either control channels or traffic channels. For example, control information is relayed from a base-station to mobile stations located in its cell over a broadcast control channel (BCCH). Speech and data information are carried between the base-station and the mobile stations by a plurality of traffic channels (TCH). Each mobile station is adapted to be able to monitor not only the BCCH transmitted by its serving base-station (in whose cell it is located) but also the BCCHs of neighbouring base-stations. These measurements can be reported back to the serving base-station and a value for C/I can be calculated. C/I is a measure of the relative interference

levels caused by the environment during a communication and thereby a measure of call quality. These levels are usually expressed as the ratio of the received signal level from the wanted source (carrier level C) to the interference received level (interference level I), or C/I and are expressed in dB. C/I values in a given cell depend on the locations of the mobile stations and on the locations of the interfering sources. Hence, they depend on cellular planning and on frequency re-use.

Capacity and coverage requirements of a GSM network can require the use of indoor cellular coverage. This can be provided by a so-called pico cells. For example, each floor of a multi-storey building may have its own cell. Served by an RF head (transceiver) located on each floor or by a distributed antenna system. This arrangement allows a mobile station to establish a call anywhere in a building and to maintain it whilst moving around the building or between floors. In-building systems must be carefully balanced so that they can co-exist with the outside "macro" cells.

In the known distributed antenna system, the RF transceivers are distributed throughout the whole building and linked to one base-station. The indoor system is configured as a unique cell with one BCCH carrier serving the whole coverage area. A gain in capacity can be achieved easily by increasing the number of RF transceivers in the building. In spite of these advantages, a drawback appears in the practical implementation which is the necessity of finding interference-free carrier frequencies in all places where coverage is provided. For a satisfactory performance of an indoor distributed antenna system, it is necessary to ensure in the deployment phase that the frequencies inside the building are not being interfered with by the external network. This requirement is often difficult to accomplish especially when the number of available indoor carrier frequencies is restricted.

This invention aims to provide a means for efficiently deploying a given spectral resource in an in-building cellular communications network.

In a first aspect, the present invention consists of a method for allocating a frequency channel to a call between a mobile station and a base-station in a cellular communications network, the network being configured to include an inner cell and a plurality of external cells surrounding the inner cell, each cell being configured to provide a broadcast control channel (BCCH) having a frequency unique to each cell, each external cell being configured to provide a traffic channel (TCH), and the inner cell being configured to provide a plurality of TCH's having frequencies in common with at least one of those provided by the external cells,

in which the method includes the steps of;

establishing a communications link between a mobile station located in the inner cell and a base-station serving the inner cell,

measuring interference levels of signals received at the mobile station located in the inner cell from at least one of the external cells,

identifying external cells whose interference levels do not meet a pre-set criterion,

and allocating the call to a channel not associated with the so-identified cells.

In a second aspect, the present invention consists of apparatus for allocating a frequency channel to a call between a mobile station and a base-station in a cellular communications network, the network being configured to include an inner cell and a plurality of external cells surrounding the inner cell, each cell being configured to provide a broadcast control channel (BCCH) having a frequency unique to each cell, each external cell being configured to provide a traffic channel (TCH), and the inner cell being configured to provide a plurality of TCH's having frequencies in common with at least one of those provided by the external cells,

in which the apparatus includes;

means for establishing a communications link between a mobile station located in the inner cell and a base station serving the inner cell,

means for measuring interference levels of signals received at the mobile station located in the inner cell from at least one of the external cells,
means for identifying external cells whose interference levels do not meet a pre-set criterion,
and means for allocating the call to a channel not associated with the so-identified cells.

Thus, by virtue of the present invention, a call to be established in a cell inside a building can be assigned to a carrier which is free of interference (or at least subjected to an acceptably low level of interference) from carriers of the same frequency generated by the external (macro) cells.

In a first embodiment, the step of measuring the interference levels takes the form of a C/I measurement performed at a mobile station or at a base station. For example, the strengths of the BCCH signal received from the serving base station and the BCCH signals received from each base-station in each surrounding external cell are measured and reported to the serving base-station. At the serving base-station, a C/I value for each surrounding cell is computed and compared with a pre-set first threshold. Those below the threshold, ie showing a high interference level are discarded. From those remaining, the serving base-station allocates to the mobile station the TCH channel associated with one of the remaining external cells, preferably the one having the highest C/I value. If all C/I measurements are below the first threshold, then the serving base-station allocates to the mobile station its own BCCH for communication. This first embodiment can be used for allocating a new incoming call.

In a second embodiment, the invention can be further extended to identify an intra-cell handover candidate as follows. Either a mobile station located in the inner cell or its serving base-station is adapted to monitor the C/I values for neighbouring cells and when a potential source of interference is detected (by comparing the C/I value with a second threshold) a handover condition is reached and a new channel with better communications quality needs to be found.

This new channel is identified by means of the process described with reference to the first embodiment mentioned above. Once identified the call is re-allocated to the new channel within the building.

The first threshold may have a single value for the network or it may be assigned different values for every carrier. The same applies to the second threshold.

The invention thus can provide dynamic allocation of frequencies for calls and, by the continuous monitoring of the interference levels, prevent the appearance of critical situations by changing the frequency assigned to any particular call.

The invention makes use of the standard process of reporting the signal strength of neighbours in order to evaluate the degree of interference at a particular external is causing to an indoor system. For this purpose, the potential external interfering cells are defined as neighbours.

Another function that the invention can provide is the ability to estimate the interference that a particular call can be suffering in order to predict quality degradation. The invention can be configured to use the signal strength values reported for the serving and neighbour cells and calculate the difference in signal level that the mobile station is receiving from both serving and interfering cells. A particular frequency can be considered suitable for use by the mobile station if the level from the interfering cell is weaker than the level from the indoor antenna within a certain protection margin.

The indoor system is configured as a single cell and the interference will come from different sources at the different locations within the building. It will affect the indoor traffic channels differently. The invention estimates interference in a particular frequency and assigns or re-allocates the call to another frequency that has been previously verified as non-interfering. In this way, the call always stays within the indoor system on the best possible frequency depending on the location of the mobile station.

Some embodiments of the invention will now be described, by way of example only, with reference to the drawings of which; Figure 1 is a schematic diagram of cellular network configured in accordance with the present invention, and Figure 2 is a schematic diagram of the network of figure 1 illustrating carrier frequency coverage areas.

In figure 1, a building 1 is configured as one communications cell and is surrounded by five neighbouring cells 2, 3, 4, 5 and 6. Each cell is served by a respective base-station 7-12 and in the case of the building 1, multiple leaky feeders (not shown) from the base-station 1 are distributed throughout the building.

The cell comprising the building 1 has a single BCCH 90 and each external cell 2-6 has its own unique BCCH designated BCCH 92, 94, 100, 98 and 96 respectively. Thus, there are six separate BCCH frequencies existing in the example of figure 1. Each external cell 2-6 also has its own unique TCH designated TCH 102, 104, 110, 108 and 106 respectively. The cell comprising the building 1 is configured to provide all five traffic channels TCH 102, 104, 110, 108 and 106. Any mobile station 13 located anywhere in the building 1 can therefore receive one BCCH (90) and can be allocated any one of the five TCH's in accordance with the allocation procedure of the invention. The leaky feeders allow all five TCH frequencies and the BCCH 90 to be received anywhere in the building.

In this embodiment, the base station 7 transmits its BCCH 90 carrier at a power level sufficient to provide good coverage inside the entire building 1 and transmits the 5 TCH carriers at a lower power compared with the BCCH 90 so that their signal level will not interfere with the external system comprising cells 2-6 with which it shares these common TCH frequencies. The external system will detect only the BCCH 90 from the building 1, but as the frequency of the BCCH 90 is unique to the network illustrated, it will not adversely affect the external system.

As TCH carrier frequencies are re-used in the building 1 from the external cells 2-6, channel allocation must be done in

a way so that adjacent channel interference and co-channel interference, to which a mobile station 13 communicating in the building is susceptible are minimised.

In order to manage call allocation in the indoor system in the building 1, each TCH carrier has those neighbour cells which contain the same TCH carrier frequency as itself are defined as potential interferes (for instance cell 4 will be a potential source of interference to TCH 110).

The decision to handle calls within the building 1 are based on measurements of C/I ratios.

In a first example, channel allocation for a new call is performed as follows. C/I measurements are made by comparing the signal strength of BCCH 90 received at the mobile station 13 from its serving base-station with each BCCH frequency received at the mobile station 13 from each neighbouring cell which contains a potentially interfering TCH.

Each C/I value obtained is then compared with a pre-determined first threshold and the cell associated with the highest C/I value above this threshold is identified. This cell will be the lowest potential interferer and so the TCH assigned to the call is that contained in the identified cell. For example, if BCCH 98 gives the highest C/I ratio, then the call is assigned to TCH 108.

If no C/I value exceeds the first threshold then the call is assigned to BCCH 90 (of the serving cell).

In a second example a handover or re-allocation of a call already in progress on a TCH to another carrier within the cell is performed as follows.

In order to assist an intra-cell handover process, C/I measurements are performed by comparing the signal strength of BCCH 90 received at the mobile station 13 with each BCCH received at mobile station 13 from all neighbouring cells which contain potentially interfering TCH's.

The C/I measurements are each compared with a second pre-set threshold. Cells associated with a C/I value which fall below this second threshold are identified as potential interferers. Of the remaining cells, the C/I measurements are

then compared with the first threshold and the TCH associated with the cell having the highest value above the threshold is identified as the best handover candidate carrier.

If all values fall below the first threshold (ie no TCH is suitable) then the best handover candidate is identified as the indoor BCCH 90.

Say, for example, that a call is currently being conducted on TCH 110. C/I values for neighbouring cells 2-6 are constantly being monitored at the base-station 7 and at some particular point during the call, the C/I values for cells 3 and 4 drop below the second threshold. This signifies that a source of interference exists which could result in a dropped call (particularly as cell 4 contains the same TCCH frequency as that in use). Therefore the base station 7 has to find a suitable handover candidate out of the remaining TCHs in common with cells 2, 5 and 6. It compares the C/I values for cells 2, 5 and 6 with the first threshold and re-allocates the call to the TCH in common with the cell having the highest C/I value above the first threshold.

Intra-cell handover can also be performed for calls already existing on the BCCH 90. When a C/I value exceeding the first threshold is detected, the TCH associated with the relevant cell is identified as a handover candidate carrier and the call is re-allocated accordingly.

The above processes ensure that the mobile station 13 is assigned to a carrier frequency free of interference from the external cells 2-6.

Handovers between radiation points where the main interfering cells change can be performed directly, when possible and only when no other non-BCCH (ie TCH carrier) is available will they take place through the BCCH. The calls are allocated when possible to TCHs in order to minimize the occupancy of the BCCH and to avoid congestion on this carrier. The BCCH is needed as a rescue layer and the resources that this carrier provides are usually limited.

A call can be transferred to a non-BCCH carrier as soon as the protection defined in the first threshold (which can be

specified on a per carrier basis) is guaranteed for all the neighbours that may interfere with the frequency allocated in the carrier. In a similar way, a call will stay in a non-BCCH carrier until protection defined in the second threshold (which can be specified by per-carrier basis) is not satisfied for any of the neighbours that may interfere with the frequency allocated in the carrier.

For every location within the building, the BCCH works as a shell, transmitting at a higher power than the TCH carriers. Only when and where the level of interference is acceptable is the TCH carrier used.

Figure 2 shows the coverage areas of each TCH contained within the in-building system. It can be seen that regions close to a particular external cell avoid using the TCH associated with that cell.

CLAIMS

1 A method for allocating a frequency channel to a call between a mobile station and a base-station in a cellular communications network, the network being configured to include an inner cell and a plurality of external cells surrounding the inner cell, each cell being configured to provide a broadcast control channel (BCCH) having a frequency unique to each cell, each external cell being configured to provide a traffic channel (TCH), and the inner cell being configured to provide a plurality of traffic channels having frequencies in common with at least one of those provided by the external cells,
in which the method includes the steps of;
(a) establishing a communications link between a mobile station located in the inner cell and a base-station serving the inner cell,
(b) measuring interference levels of signals received at the mobile station located in the inner cell from at least one of the external cells,
(c) identifying external cells whose interference levels do not meet a pre-set criterion,
(d) and allocating the call to a channel not associated with the so-identified cells.

2 A method according to claim 1 in which the step of measuring interference levels includes the step of monitoring a C/I (carrier to interference) ratio.

3 A method according to claim 2 in which the step of identifying external cells includes comparing a C/I ratio with a first threshold.

4 A method according to claim 3 in which the first threshold has a plurality of values, each value being peculiar to each traffic channel provided in each external cell.

5 A method according to any of claims 2-4 in which the step of allocating includes the step of allocating the call to a traffic channel associated with an external cell having the highest C/I ratio above the first threshold.

6 A method according to either of claims 3 or 4 in which the step of allocating includes the step of allocating the call to the inner cell's BCCH when no C/I ratios exceed the first threshold.

7 A method according to any of claims 1-4 including after step (b) and prior to step (c) the further steps of,

(e) detecting external cells whose interference levels do not meet a further pre-set criterion,
(f) and eliminating said detected cells from subsequent steps.

8 A method according to claim 7 in which the step of detecting includes comparing a C/I ratio with a second threshold.

9 A method according to claim 8 in which the second threshold has a plurality of values, each value being peculiar to each traffic channel provided in each external cell.

10 Apparatus for allocating a frequency channel to a call between a mobile station and a base-station in a cellular communications network, the network being configured to include an inner cell and a plurality of external cells surrounding the inner cell, each cell being configured to provide a broadcast control channel (BCCH) having a frequency unique to each cell, each external cell being configured to provide a traffic channel (TCH), and the inner cell being configured to provide a plurality of traffic channels having frequencies in common with at least one of those provided by the external cells,
in which the apparatus includes;

means for establishing a communications link between a mobile station located in the inner cell and a base station serving the inner cell,

means for measuring interference levels of signals received at the mobile station located in the inner cell from at least one of the external cells,

means for identifying external cells whose interference levels do not meet a pre-set criterion,

and means for allocating the call to a channel not associated with the so-identified cells.

11 A method for allocating a frequency channel substantially as herein before described with reference to the drawings.

12 Apparatus for allocating a frequency channel substantially as herein before described with reference to the drawings.

CHARTER MARK

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Application No: GB 0003562.6
Claims searched: 1 to 12

Examiner: Glyn Hughes
Date of search: 6 August 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4L (LDSWD, LDSWX)

Int Cl (Ed.7): H04Q 7/36, 7/38

Other: Online: WPI, JAPIO, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2260879 A (MATSUSHITA) see whole document	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

(12) UK Patent Application (19) GB (11) 2 357 224 (13) A

(43) Date of Printing by UK Office 13.06.2001

(21) Application No 0105394.1

(22) Date of Filing 13.07.1999

(30) Priority Data
(31) 09134202 (32) 14.08.1998 (33) US

(86) International Application Data
PCT/SE99/01262 En 13.07.1999

(87) International Publication Data
WO00/10355 En 24.02.2000

(51) INT CL^7
H04Q 7/36

(52) UK CL (Edition S)
H4L LRRMD

(56) Documents Cited by ISA
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(58) Field of Search by ISA
INT CL^7 H04Q 7/36

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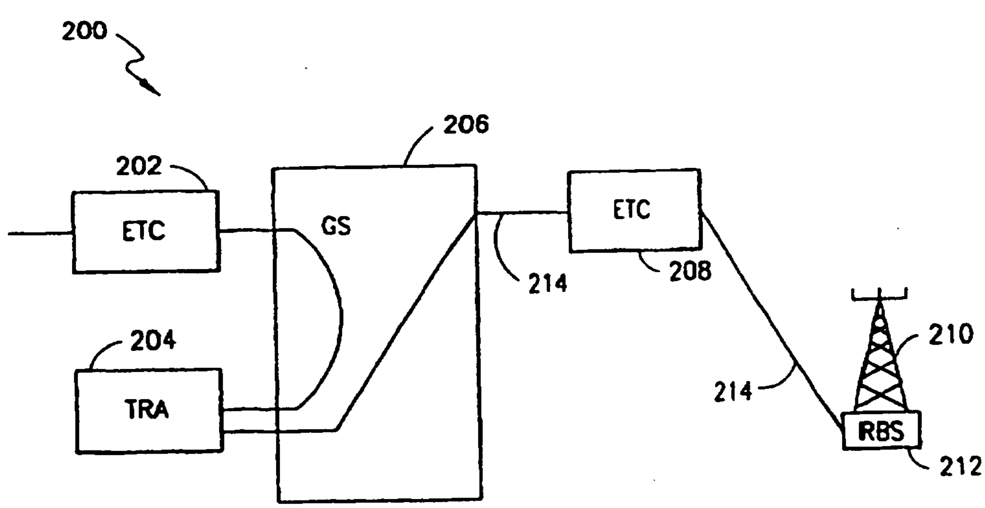
(54) Abstract Title
Method and system for improving network resource utilization in acellular communication system

(57) A hierarchically structured cellular network is disclosed. When an active mobile station requests a service that requires the use of a network resource not available in the cell handling the ongoing call (or, alternatively, during call set up), the network checks for cells on the higher levels to determine if the required resource is available. If the resource is available in a higher level cell, the call is handed over to that cell and the resource is allocated to the call. The call can be maintained in the higher level cell until the resource is no longer needed, or a "better" cell capable of providing the required resource is found.



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PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04Q 7/36

A1

(11) International Publication Number: WO 00/10355

(43) International Publication Date: 24 February 2000 (24.02.00)

(21) International Application Number: PCT/SE99/01262

(22) International Filing Date: 13 July 1999 (13.07.99)

(30) Priority Data:
09/134,202 14 August 1998 (14.08.98) US

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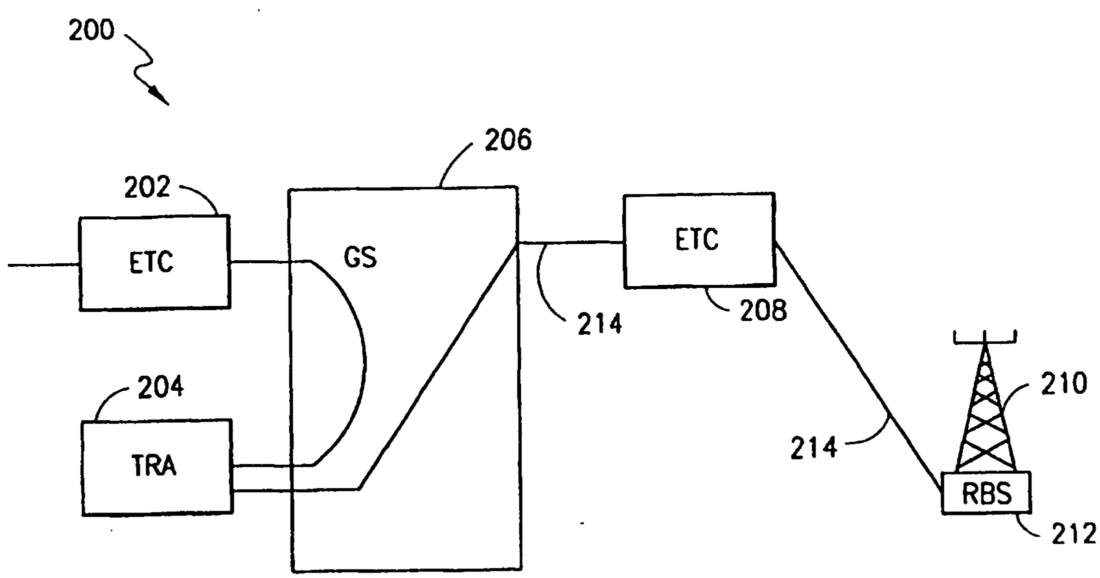
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND SYSTEM FOR IMPROVING NETWORK RESOURCE UTILIZATION IN ACELLULAR COMMUNICATION SYSTEM



(57) Abstract

A hierarchically structured cellular network is disclosed. When an active mobile station requests a service that requires the use of a network resource not available in the cell handling the ongoing call (or, alternatively, during call set up), the network checks for cells on the higher levels to determine if the required resource is available. If the resource is available in a higher level cell, the call is handed over to that cell and the resource is allocated to the call. The call can be maintained in the higher level cell until the resource is no longer needed, or a "better" cell capable of providing the required resource is found.

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METHOD AND SYSTEM FOR IMPROVING NETWORK RESOURCE UTILIZATION IN A CELLULAR COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates in general to the mobile communications field and, in particular, to a method and system for improving utilization of network resources with handovers in a cellular communication system.

Description of Related Art

A hierarchical (layered) cell structure can be used as one approach to obtain higher network capacities in mobile radiotelephone systems. For example, Hierarchical Cell Structures (HCSs) are being used in Personal Digital Cellular (PDC) System radio networks in Japan, so that cells of different sizes can be used to cover the same geographical areas. Using such a hierarchical cell structuring approach, the PDC networks' radio channel frequencies can be re-used to a much greater extent than with conventional cell structures, which results in higher capacity (traffic load). In that regard, a hierarchically structured network can employ a handover procedure to order a mobile station (MS) to move from one radio channel frequency to another in the same cell or a different cell.

A problem that arises with such cell structuring approaches is that certain, special communication resources provided by the radio networks are not necessarily maintained and made available in cells at all levels, especially in those networks where higher capacities are desired. An example of such a resource typically not made available in lower level cells is a full-rate traffic channel, or a circuit-switched data transmission service. In radio networks utilizing a HCS, the operators typically configure the networks to provide these resources in the higher level, broader coverage cells (e.g., layer 3 or "umbrella" cells in a three-layered HCS network). As such, in existing mobile systems, an MS accesses the "best" (e.g., higher carrier-to-interference or carrier-to-adjacent ratio) available cell in the radio network. The network then assigns a traffic channel (TCH) to the MS in a cell on the lowest possible level.

Consequently, when an active MS requests a service that requires the use of a specific resource (e.g., full-rate traffic channel, or circuit-switched data transmission service), and if that resource is not available in the cell handling the ongoing call, the requested service will not be provided for that call. Therefore, the network will most likely disconnect that call. However, as described in detail below, the present invention successfully resolves this problem and other related problems.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, in a HCS network, when an active MS requests a service that requires the use of a network resource not available in the cell handling the ongoing call (or, alternatively, during call set up), the network checks for cells on the higher levels to determine if the required resource is available. If the resource is available in a higher level cell, the "call" is handed over to that cell and the resource is allocated to the call. The call can be maintained in the higher level cell until the resource is no longer needed, or a "better" cell capable of providing the required resource is found.

An important technical advantage of the present invention is that a network operator can create a radio network plan based on the capacities of different communication resources.

Another important technical advantage of the present invention is that network resource utilization is increased significantly over conventional approaches.

Yet another important technical advantage of the present invention is that the flexible resource utilization allows more calls to be set up in the lower layer cells, which allows mobile stations to transmit at lower power levels and thus save battery power.

Still another important technical advantage of the present invention is that the flexible resource utilization that allows more calls to be set up in the lower layer cells, also reduces the total interference level in the network.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagram that illustrates an exemplary hierarchical cell structure for a mobile radiotelephone network, which can be used to implement a preferred embodiment of the present invention;

FIGURE 2 is a simplified block diagram of an exemplary cellular network that can be used to implement the preferred embodiment of the present invention; and

FIGURE 3 is a simplified block diagram that illustrates an exemplary mobile base station subsystem that can be associated with one or more mobile services switching centers and radio base stations in the cellular network shown in FIGURE 2 to implement the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention and its advantages are best understood by referring to FIGUREs 1-3 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

Essentially, in accordance with a preferred embodiment of the present invention, in a hierarchically structured or layered cellular network, when an active MS requests a service that requires the use of a network resource not available in the cell handling the ongoing call, the network checks for cells on the higher levels to determine if the required resource is available. If the resource is available in a higher level cell, the "call" is handed over to that cell and the resource is allocated to the call. The call can be maintained in the higher level cell until the resource is no longer needed, or a "better" cell capable of providing the required resource is found.

Specifically, FIGURE 1 is a diagram that illustrates an exemplary hierarchical cell structure (10) for a mobile radiotelephone network, which can be used to implement a preferred embodiment of the present invention. The exemplary HCS 10 shown represents a three-layer cell structure, with at least one "umbrella" cell 12 at the highest level (e.g., layer 3), a plurality of "normal" cells 14, 16 at the next lower level (e.g., layer 2), and a plurality of "micro" cells 18, 20, 22, 24 at the lowest level (e.g.,

layer 1) in the hierarchy. Notably, although not explicitly shown, the radio network can include more than one of such "umbrella" cells, along with corresponding sets of "normal" and "micro" cells. Also, the HCS concept described herein can be extended to include one or more additional levels of cells (e.g., so-called "pico" cells and/or "macro" cells).

FIGURE 2 is a simplified block diagram of an exemplary cellular network (100) that can be used to implement the preferred embodiment of the present invention. The exemplary network 100 includes a gateway mobile services switching center (GMSC) 102 connected to a home location register 104 and a plurality of MSCs 106, 110. Essentially, the GMSC 102 functions to connect the network 100 to other networks, and is the entry/exit point for calls from/to other networks to/from mobile subscribers. The HLR 104 is a database that contains subscriber information including the current location of the subscribers' MSs in the network. The MSCs 106, 110 in combination with their respective gateway location registers (GLRs) 108, 112 control the routing of calls, location registrations, and handovers. The GLRs 108, 112 are databases that are responsible for storing and updating subscriber information for the MSs located in their respective MSC/GLR coverage areas. The MSCs 106, 110 are connected to a respective plurality of radio base stations (RBSs) 114-121, each of which defines a cell. As described in detail below, certain of the cells defined by the RBSs 114-121 can represent certain of the cells 12-24 shown in FIGURE 1. The subscribers' MSs (not shown) are connected to an MSC 106 or 110 via a radio air interface and an RBS 114-121.

FIGURE 3 is a simplified block diagram that illustrates an exemplary mobile base station subsystem (MBS) 200 that can be associated with one or more of the MSC/GLRs and RBSs in the cellular network 100 (FIGURE 2) to implement the preferred embodiment of the present invention. For example, an MBS (200) associated with the MSC/GLR 106/108 can provide communications resources for certain of the RBSs (e.g., 114, 116) and the cell or cells defined thereby (e.g., "umbrella" cell 12 or "normal" cells 14, 16 in FIGURE 1). At this point, it is useful to describe some exemplary communications resources (and associated concepts) that can be provided by the MBS shown.

In the context of a PDC system (but not limited to just this system), the RBSs 114, 116 can include dual rate equipment that provides resources capable of carrying full rate and half rate connections. Such dual rate equipment provides three dual rate channel pairs. As such, the "channel rate" (e.g., full rate or half rate) indicates the channel rate currently in use for a traffic channel. A "dual rate channel pair" denotes the channels on dual rate equipment that together provide a resource capable of carrying one full rate connection or two half rate connections. Such a dual rate channel pair comprises the channels corresponding to the radio air interface time slots TS0/TS3, TS1/TS4, or TS2/TS5.

A "dual rate traffic channel" denotes a traffic channel included in a dual rate channel pair, which is capable of carrying a half rate connection. Together with the other channel in the dual rate channel pair, the dual rate traffic channel is capable of carrying a full rate connection. A full rate traffic channel represents a traffic channel carrying a full rate connection. In the PDC radio air interface, for example, a full rate traffic channel corresponds to one full rate time slot, TS0-TS2. One full rate time slot corresponds to two half rate time slots. A half rate traffic channel represents a traffic channel carrying a half rate connection. In the PDC radio air interface, for example, a half rate traffic channel corresponds to one half rate time slot, TS0-TS5.

Returning to FIGURE 3, the exemplary MBS 200 includes a plurality of exchange terminal circuits (ETCs) 202, 208, which function as trunk interfaces (e.g., bit rate adapters) between the group switch 206 and other networks and transceiver (TRX) 212 in the RBS 210. The group switch 206 can switch the calls in order to include or exclude the transcoder rate adaptor (TRA) 204 in or out of the connection. The TRA-TRX link 214 is a connection between the TRA 204 and TRX 212, which can carry a plurality of full, half, or dual rate speech channels.

In this embodiment, the traffic functions in the MBS 200 handle the radio channel connections in this part of the network 100, which includes, for example, controlling certain physical channels, handling all logical channels, and controlling the RBS 210 and TRA 204 in the MSC (106). The TRA 204 performs a rate conversion from the 64 kbps Pulse Code Modulation (PCM) links used in the group switch 206 and trunk lines to the rates used in the speech connections. As such, the group switch 206 can switch the TRA 204 into the connection if a rate conversion is needed.

Depending on the traffic, the TRA 204 can operate in a number of different modes. In one mode, the TRA 204 converts 11.2 kbps Vector-Sum Excited Linear Prediction (VSELP) encoded speech data (speech connection for the network MSs involved) into a 64 kbps μ-law PCM coded speech signal. This mode is used when the network MS is connected to any terminal other than another network MS. In a second mode of operation, if there is a call from one network MS to another network MS, the TRA 204 does not convert the signal from the MS, but transports the 11.2 kbps VSELP encoded speech signal to the network using a 64 kbps unrestricted digital channel. This mode is valid only for full rate channels in the PDC, and is used to eliminate the potential for encoding/decoding the speech data twice, which could have occurred because of the MS-to-MS call. In a third mode of operation, the TRA 204 can operate in a non-speech data mode (e.g., circuit-switched data transmission service mode). In the PDC, this mode is valid only for full rate channels.

For this example, it can be assumed that the lower layer cells (e.g., 14, 16) in the network 10 can provide multiplexing for each TRX used. As such, in the PDC, two TRA-TRX links 214 in each of these cells can be multiplexed into one 64 kbps time slot. Consequently, given this resource limitation, only one circuit-switched data transmission service call per TRX (e.g., 212) can be set up in each of these cells. In other words, the capacity for carrying circuit-switched data transmission service calls is relatively low in the lower layer cells.

On the other hand, for this PDC example, it can be assumed that no multiplexing is provided for the TRXs (212') in the higher layer cells (e.g., 12) in the network. Consequently, given the absence of this resource limitation, all three of the time slots used by each TRX (212') can carry circuit-switched data transmission service calls. In other words, the capacity for carrying circuit-switched data transmission service calls is relatively high in the higher layer cells (e.g., 12).

More specifically with respect to the network exemplified by FIGUREs 1-3, assume that each RBS 210' (or, for example, 114, 116) that defines the higher layer cells (e.g., 12) includes 10 TRXs, with each TRX capable of handling 3-6 speech channels or 1-3 non-speech (data) channels. Also, each RBS 210 (or, for example, 118, 120) that defines the lower layer cells (e.g., 14, 16) includes 2 TRXs, with each such TRX capable of handling 3-6 speech channels or 1-3 non-speech channels.

Under this scenario, if the lower layer cells (e.g., 14, 16) are using multiplexing on the respective TRA-TRX links (e.g., 214), then each of these lower layer cells can set up only two non-speech calls.

In a conventional network, if there were two such ongoing calls in one of these lower layer cells, and a third call were to request a circuit-switched data transmission service in that cell, then the network would refuse to provide the circuit-switched data transmission service resource for that call. Ultimately, the network likely would disconnect that call. However, in accordance with the preferred embodiment of the present invention, the network 10/100 determines whether the higher layer cell (12) has channels available (e.g., not in use) that can carry the requested circuit-switched data transmission service, and performs a conventional inter-cell handover for that MS and call, from the lower layer cell to an appropriate channel in the higher layer cell. The MSC/GLR (106/108) stores pertinent information about which resources are available in which cells, and controls the inter-cell handover procedure. The requested circuit-switched data transmission service is then provided for that call by the resource in the higher layer cell. Notably, although the exemplary embodiment described above deals with a hierarchical relationship between cells 12 and 14, 16, the invention is not intended to be so limited. For example, the hierarchical relationship and inter-cell handover can be between one of the lower layer cells 18, 20, 22, 24 and one of the higher layer cells 14, 16. In summary, if a service/resource is not provided by one (layer) cell, but can be provided by another (layer) cell, then (in accordance with the present invention) the network can hand over the MS making the call (and requesting the service) to a cell in the layer capable of handling that service and call. The network can maintain the call in the cell capable of handling that service, until the call is disconnected, the "special" resource is no longer required for that call, or a "better" cell with appropriate resources that can provide the service is found. In the last case, the network MSC can then institute a hand over to transfer the call to the "better" cell.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements,

modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A method for improving communication resource utilization in a layered cellular network, comprising the steps of:

invoking a service associated with a communication resource during a call in a first layer cell;

determining whether said communication resource is available during said call in said first layer cell;

if said communication resource is not available during said call in said first layer cell, determining whether said communication resource is available during said call in a second layer cell;

if said communication resource is available during said call in said second layer cell, handing off said call from said first layer cell to said second layer cell.

2. The method of Claim 1, wherein said call comprises a call set up procedure.

3. The method of Claim 1, wherein said first layer cell is a lower level cell than said second layer cell.

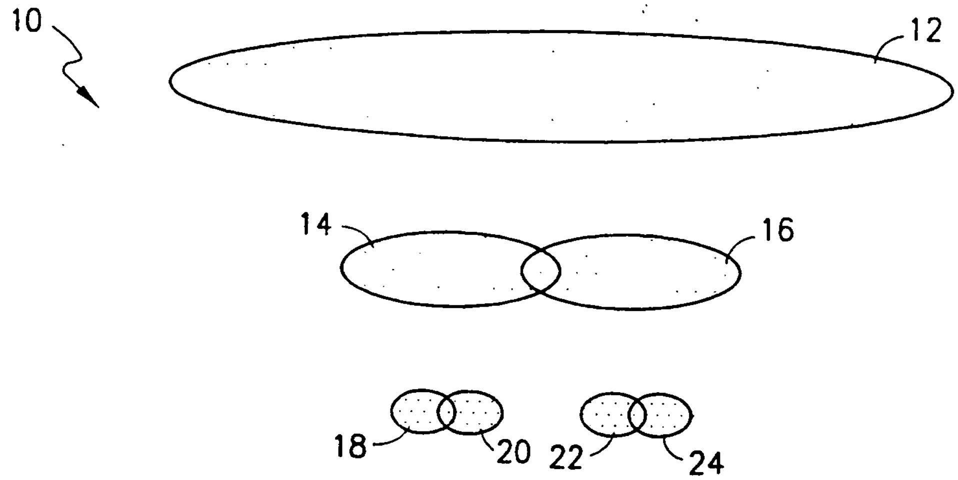
4. The method of Claim 1, wherein said layered cellular network comprises a hierarchical cell structure.

5. The method of Claim 1, wherein said layered cellular network comprises a layered PDC network.

6. The method of Claim 1, wherein said communication resource comprises a full rate traffic channel.

7. The method of Claim 6, wherein said service comprises a data service.

8. The method of Claim 6, wherein said service comprises a circuit-switched data transmission service.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12
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FIG. 1

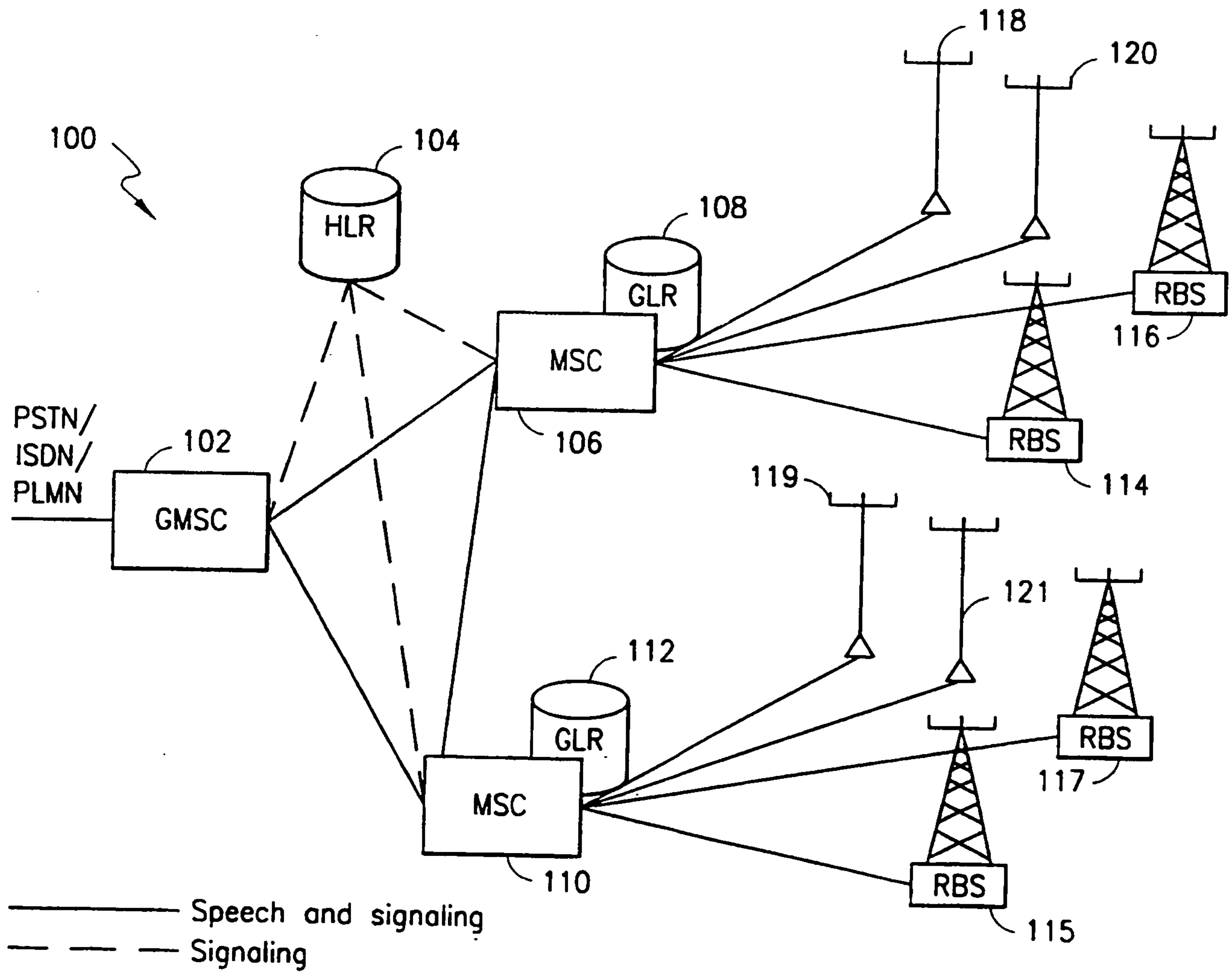
100
104
HLR
108
GLR
MSC
106
118
120
RBS
116
RBS
114
PSTN/
ISDN/
PLMN
102
GMSC
119
121
112
GLR
MSC
110
RBS
117
RBS
115
Speech and signaling
Signaling

FIG 2

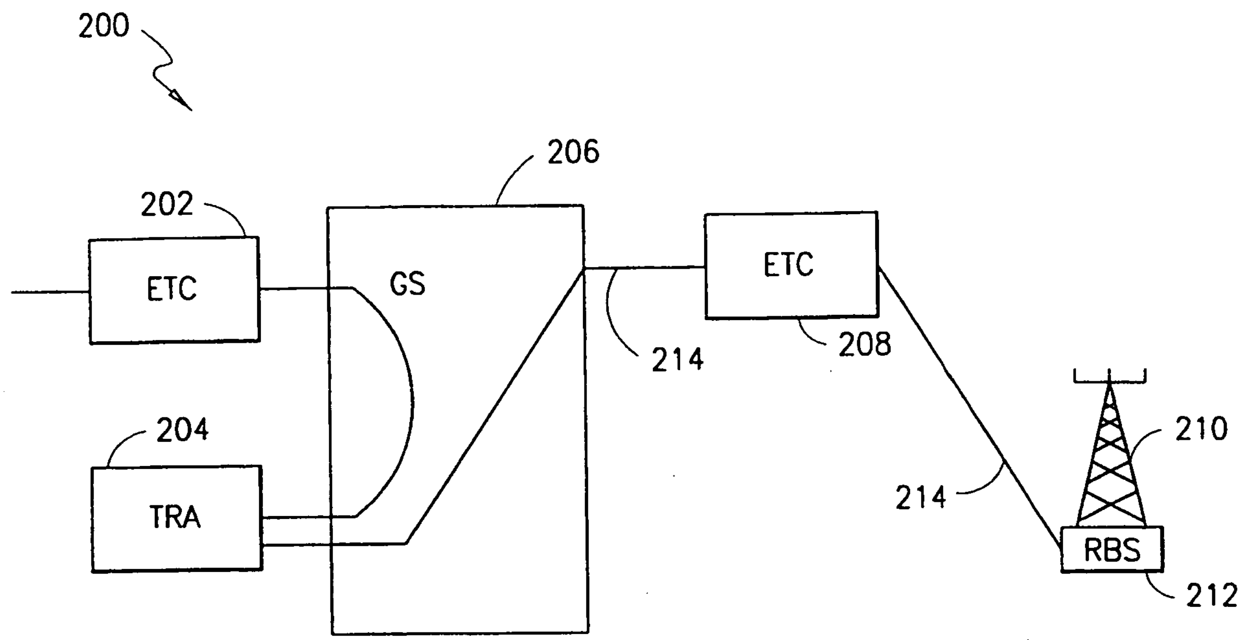

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/01262

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LIN Y -B ET AL: "MODELING HIERARCHICAL MICROCELL/MACROCELL PCS ARCHITECTURE" COMMUNICATIONS - GATEWAY TO GLOBALIZATION. PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, SEATTLE, JUNE 18 - 22, 1995, vol. 1, 18 June 1995 (1995-06-18), pages 405-409, XP000533019 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS the whole document ---	1-4, 9-15,20, 21
A	POLLINI G P: "TRENDS IN HANDOVER DESIGN" IEEE COMMUNICATIONS MAGAZINE, vol. 34, no. 3, 1 March 1996 (1996-03-01), pages 82-90, XP000557380 -----	

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
17 November 1999	24/11/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Heinrich, D

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